

"By an inspection of the numerous spectra my opinion is strengthened that in arranging stars according to their spectra only general marked characteristics should be considered, and a rational classification can only be thought of if based on the supposition that the various stellar spectra indicate different phases of development.

"I think it is much to be regretted that, in the extensive spectroscopic examination of all stars down to about the seventh magnitude, which Pickering by means of an objective prism has undertaken, the classification of stars, based on no general grounds, but only according to the appearance of the spectrum, which is very often misrepresented by incorrect exposure, especially in the case of brighter stars, leads him to adopt sixteen classes, denoted by the letters A-Q."

On this it may be remarked that Mr Lockyer has already shown in NATURE that Prof. Pickering's classification is quite philosophical, and that, moreover, it brings stars together to which he also has assigned special places in his classification on account of their special features.

Prof. Vogel then continues:—

"The attempt, on the lines mentioned above, which I made twenty years ago, with regard to the classification of stellar spectra has for the most part been corroborated, in spite of the great progress of stellar spectroscopy during the last few years, namely by the fine detailed researches of their spectra by Scheiner.

"In relation to the stars of Class III., direct observation of the less refrangible part of the spectrum of the photograph is yet to be considered. Of my two suggested divisions, *a* and *b*, the criterium as to which belongs to the more advanced stage of development is entirely absent. One can only say this, that in both divisions the atmospheres of the stars have so far cooled as to stop the dissociation of the materials and allow compounds to be formed. There is therefore, no reason given why stars of Class III.*b*, in which chiefly the absorption bands are produced by carbon compounds, should be placed in a special Class IV. For the same reason direct observation is a good means of recognising spectra of Class II. Also here there is no reason to adopt subdivisions other than the two already assumed by me before we are in possession of more accurate investigations of the spectra of Class II.*b*.

"It is different in the case of the spectra of Class I. In these spectra the application of photography makes it in general possible to step further and obtain more minute points of difference than was the case before. It appears also that the study of the spectrum of these stars is of special interest, inasmuch as, starting from the simplest spectrum, in which only hydrogen lines are visible, the first traces of a further development can be found by the appearance of lines of other substances, and we can follow them up to the numberless lines exhibited in the spectra of Class II. Perhaps it will be possible by a more extended investigation of the details of the spectrum of Class I. to find the first beginnings and individual parts of both from successive series, the extremities of which, so different in appearance, are spectra of the type of Class III.*a* and III.*b*.

"The observations mentioned above have led me to the opinion that the appearance of the lines of cleveite gas in stellar spectra, if closely watched, may give us a good basis for the classification of these spectra.

"The spectrum appearance of cleveite gas has such a similarity with that of hydrogen, as has long been known to be the case, through the constant appearance of the D_{β} line with the hydrogen lines at all parts of the chromosphere of the sun, as well as in the prominences, that one may expect to find, after the appearance of the hydrogen lines in the first place, that of the lines of cleveite. The paucity in lines of the spectrum of this gas makes it especially easy to be at once recognised. Although the brightest line, $\lambda 388.9 \mu\mu$, as already mentioned, falls so near constantly the present hydrogen line $H\zeta$ in the spectrum of Class I. that a separation is impossible, and although in only very few cases does the sum-total of both these strong lines appear distinct—as, for instance, in the spectrum of β Lyra—the lines $\lambda 382.00 \mu\mu$, $\lambda 386.8 \mu\mu$, $\lambda 402.6 \mu\mu$, and $\lambda 447.2 \mu\mu$, on the other hand, and those in the less refrangible part of the spectrum, namely $\lambda 492.2 \mu\mu$, $\lambda 501.6 \mu\mu$, and D_{β} , $\lambda 587.6 \mu\mu$, are so easy to find and recognise that the proof of the presence of cleveite gas is not beset with difficulties.

"As a second point of difference for subdivisions of Class I. the presence of the calcium lines $\lambda 393.38 \mu\mu$ and $\lambda 396.86 \mu\mu$ is convenient, the second of these lines coinciding nearly with

the hydrogen line $H\epsilon$ ($\lambda 397.02 \mu\mu$). If the first of these lines be thin and sharp, the second only influences the hydrogen line $H\epsilon$ to a very small extent. If the lines of calcium increase both in intensity and breadth, then $H\epsilon$ broadens in a very distinct manner; both lines then very soon excel with respect to intensity and thickness, the strongest and broadest hydrogen lines in the spectra of Class I. On further development they form together the characteristic pair of lines in Class II. which Fraunhofer called H."

Prof. Vogel then concludes his paper with a re-division of stars of the first class into three parts, *a*, *b*, and *c*.

Although *c* includes stars having spectra which exhibit bright lines, he suggests that from the present point of view it would be perhaps better to place them first, as they represent the first stage of development. The fact that they are here retained in subdivision *c* is because a definite conclusion has not yet been arrived at as to their true position, so the old position has, *pro tempore*, been maintained.

THE RÖNTGEN RAYS.

THE following is a summary of some of the work with Röntgen rays brought under our notice during the past week:—

The results of a scientific study of the properties of Röntgen rays are stated in a paper by Prof. G. Vicentini and Dr. G. Pacher, in a paper read before the Reale Istituto Veneto di scienze, lettere, ed arti, on January 26, and now issued as an excerpt from the *Memorie* of the Institute (vol. xxv. No. 7). The authors found distinct evidence of an irregular reflection from a parabolic brass mirror; the Crookes' tube and the sensitive plate were placed on opposite sides of an iron plate, so that the rays to reach the plate had to be reflected from the mirror. No effect was observed with a similar glass mirror, or with the arrangements used by previous observers to test the existence of reflection. Photographs accompany the paper, showing shadows of fish, a hand, two feet, and a rat with mercury introduced into its intestines. Experiments showed that a gold-leaf electroscope, turned towards the cathode, became charged positively; a wire cage, however, completely annulled the action. The following list of transparencies to Röntgen rays is interesting:—Solid bodies (opaque): Potassium, phosphorous, fused sulphur, glass, sealing-wax, tin, zinc, iron, brass, copper, lead, platinum, mercury, crystallised sulphur, rock-salt, quartz, calc-spar, fluor-spar, topaz, beryl, aragonite, baryta, lead carbonate, tourmaline, borax. Semi-transparent: Aluminium, sodium, ebonite, retort-carbon, mica (along both axes). Transparent: Cardboard, wax, paraffin, sugar, wood-charcoal, amber, shellac. Liquid bodies (opaque): Carbon disulphide, sulphuric acid (saturated solutions of), sulphates of zinc, copper, iron, cobalt, nickel and magnesium, bichloride of mercury, chlorides of sodium, ammonium and platinum, neutral oxalate of potash, potassium bichromate, and ammonium nitrate. Semi-transparent: Acetic acid, nitric acid, glycerine, ammonia, and, in a less degree, distilled water and alcohol. Transparent: Ether, benzene, in a less degree vaseline, petroleum, aniline, and olive oil. There appeared to be no clear relation between the opacity and density of the substances experimented upon.

In order to get distinct shadows of objects opaque to Röntgen rays, it is obviously necessary to avoid a penumbra, by employing a source of the rays approaching as nearly as possible to a point. The Crookes' tubes, however, as usually put on the market, are given a pear-shape, for the purpose of having as extended an area as possible under the action of the cathode rays. To obtain clear shadows with such a tube the objects must be very close to the sensitive plate or the fluorescent screen, a condition which cannot always be realised if the objects are enclosed in envelopes of considerable thickness. Prof. E. Salvioni described to the Accademia Medico-Chirurgica di Perugia, on February 22, two methods whereby the cathode rays may be brought to a point on the walls of the tube, producing a very restricted but intensely fluorescent area. In Crookes tubes, with the usual spherical cup-shaped cathode, the rays issue from this normally, and meet in a point generally inside the tube. By moving a magnet in the neighbourhood of the tube, this focus may be brought on to the tube wall. A more convenient method of arriving at the same result was found by chance. On moving the hand over the tube, the position of the focus of the cathode rays is altered, and the same action takes place on touching the tube

with a metallic point connected to the ground or to the kathode. The rays then are attracted to a point on the tube exactly opposite to that touched by the conductor; the best position for the latter is at a distance from the kathode equal to its radius of curvature. Tubes could, of course, be constructed so that the focus of the kathode rays fell normally on the wall of the tube; it is found, however, that after some time the glass loses its fluorescent property, showing a dark spot at the incident point of the rays. The device with the metallic point enables the fluorescent spot to be changed from time to time.

The surgical aspects of photography with Röntgen rays are considered by Mr. Albert Carless in the March number of the *Practitioner*. The conclusion arrived at with reference to radiography is "that it can be of real value in a certain limited number of cases there can be no doubt, but unless very considerable improvements are made in the technique, it will be but little resorted to in practical work."

Prof. M. J. Pupin contributes to the March number of the *Engineering Magazine* (New York) an account of his experiments with Röntgen rays. He has obtained excellent results with a pear-shaped Crookes' tube, of five inches diameter, excited by a six-plate Holtz machine. He finds that a cylindrical vacuum tube without internal electrodes, but with external tinfoil coatings at the extremity of the tube, will do very well as a substitute for a Crookes' tube.

Our American correspondent writes, under date February 28: "The new art of 'radiography' is still prosecuted in America with unabated ardour. The most successful apparatus yet devised seems to be that of Prof. John S. McKay, of the Packer Institute, Brooklyn. It is a small tube five inches long, and an inch, or rather more, in diameter, which is known and sold by instrument-makers as a 'perfect vacuum' tube. This is attached directly to the terminals of the secondary coil. The copper electrodes are less than an eighth of an inch apart; but the vacuum is so perfect, that the spark will leap the whole length of the tube outside rather than cross this small interval inside. The tube produces very little light, and is sometimes, when in use, perfectly dark. This tube is light and convenient, and does not become hot like the Crookes' tube. After running it continuously for half an hour with a pressure of 200,000 volts, it is scarcely warm to the touch. But the special advantage is that the rays radiate in all directions from the centre, so that exposures may be made simultaneously within a radius of two feet from the centre of the tube. The best results were found at a distance of one foot, and with an exposure of five minutes. Experiments to determine the relative opacity of different substances show that the opacity to X-rays is generally in inverse proportion to the diathermancy of the substances tested. Thus rock-salt is most opaque; next comes alum, then glass, then quartz. Camphor gum, gum copal, and vulcanite are almost equally transparent; amber somewhat less so, and sealing-wax quite opaque. Iceland spar, mica, and selenite are quite transparent. Iceland spar seemed to give evidence of double refraction. Charcoal is quite transparent, more so than wood. Anthracite coal is somewhat opaque, but not so much as glass. Egg-shells, like bones, are opaque. Of liquids tested, mercury, sulphuric acid, glycerine, and kerosene were somewhat opaque, the opacity varying about as the density. Prof. McKay has also produced pictures on a sensitive gelatine film wrapped in paper with some metallic object upon it, and placed in the dielectric of an electric condenser, the terminals of which are connected with an induction coil or Holtz machine. After rapidly charging and discharging this condenser or Leyden jar for two or three minutes, a distinct image of the metallic body is found to be radiographed upon the sensitive film.

"A remarkable application of Prof. McKay's apparatus has been made by Edward P. Thompson, an electrician, who has devised a fluorescent screen on which shadows may be thrown showing the action of the bones in motion, as of the hand, and he hopes to show the motion of the bony skeleton of a bird in flight. It has been stated that the great drawback to aerial locomotion is our ignorance of the exact way in which a bird flies. Hence the inventor attaches much importance to his apparatus, which he calls the 'kinetoscotroscope.' It will show, among other things, the motion of the parts of a broken bone, indicating the locality and nature of the fracture, as the bones may be moved or bent back and forth before the screen, thus opening and closing the crack. The taking of pictures is not the design of this apparatus. The fluorescent screen is prepared by pulveris-

ing barium platino-cyanide to a fine powder, and pouring upon a draughtsman's tracing cloth a small quantity of varnish, or of a mixture of oil and turpentine, stirring the powder in with it, and drying."

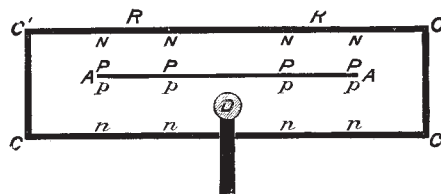
With regard to seeing Röntgen shadows by means of a fluorescent screen, Mr. Swinton informs us that he finds that instead of employing blotting-paper saturated with barium platino-cyanide, it is much better to make a hot emulsion of the barium platino-cyanide in gelatine and water, and apply this in a thick coat to a piece of glass. On cooling, the barium platino-cyanide crystallises out, and the gelatine protects it from abrasion. A thick and uniform coating is what is wanted. The glass being rather opaque to the X-rays, but transparent to light, the plate should be obviously placed with the gelatine side next to the Crookes' tube, and the glass side next the eye.

ON THE GENERATION OF LONGITUDINAL WAVES IN ETHER.¹

IN a short note published in *NATURE* of February 6, I suggested an arrangement of four insulated and electrified spherical conductors with their centres in one line, giving rise to ethereal waves in the surrounding atmosphere, of which the disturbance in the line of centres is essentially longitudinal. But at any finite distance from this line there must also be laminar or distortional waves of the kind expressed in Maxwell's equations. The object of my present communication is to show an arrangement by which a large space of air is traversed by pressural disturbance, or by waves essentially longitudinal, or by condensational-rarefactional vibrations; with but a very small proportion, practically evanescent, of laminar waves.

Let AA be a plane circular metal plate insulated within a metal case CCC', as indicated in the drawing. Let D be a discharger which can be pushed in so as to make contact with A.

Let A be charged to begin with, positively for instance as indicated by the letters PPPP; NNNN showing negative electricity



induced by it. Let now the discharger be pushed in till a spark passes. The result, as regards the space between AA and the roof RR over it, will be either an instantaneous transmission of commencement of diminution of electrostatic force, or a set of electric waves of almost purely longitudinal displacement, according as ether is incompressible or compressible.

Hence, if the theory of longitudinal waves, suggested by Röntgen as the explanation of his discovery (for the consideration of which he has given strong reasons), be true, it would seem probable that a sensitive photographic plate in the space between AA and RR should be acted on, as sensitive plates are, by Röntgen rays. Either a Wimshurst electrical machine or an induction-coil, adapted to keep incessantly charging AA with great rapidity so as to cause an exceedingly rapid succession of sparks between D and A, might give a practical result. In trying for it, the light of the sparks at D must be carefully screened to prevent general illumination of the interior of the case and ordinary photographic action on the sensitive plate.

The arrangement may be varied by making the roof of sheet aluminium, perhaps about a millimetre thick, and placing the sensitive photographic plate, or phosphorescent substance, on the outside of this roof, or in any convenient position above it. When a photographic plate is used there must, of course, be an outer cover of metal or of wood, to shut out all ordinary light from above. This arrangement will allow the spark gap at D to be made wider and wider, until in preference the sparks pass between AA and the aluminium roof above it. The transparency of the aluminium for Röntgen light will allow the photographic plate to be marked, if enough of this kind of light is produced in the space between the roof and AA, whether with or without sparks.

¹ A paper by Lord Kelvin, read before the Royal Society on February 13